Space Weather Technical Forecast

Issued on Saturday, 06 May 2023 at 13:28 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: R1-R2 Radio Blackouts throughout. Low confidence CME arrivals day 2 (07 May) bring a likelihood of G1-G2 Minor/Moderate storms with a chance of G3/Strong Storms.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate with one M-class flare observed from AR3296, peaking M2.1 at 05/0801UTC. This is one of a trio of sunspots regions in the northeast disc that appear interconnected in magnetic imagery. AR3296 is the most interesting as an anti-Hale cycle region (reverse polarity), however all three sunspot appear to have stabalised somewhat with no notable growth ongoing. The only growth is some small development around the leader of AR3299 in the southeast disc, however this remains a small and simple region. There are three further, but magnetically simple spots. No Earth-directed CMEs have been observed in this period. The large CME to the southwest and another CME to the northwest have been assessed as far-sided, while a further weak CME to the east has been assessed as missing behind Earth.

Solar Wind / Geomagnetic Activity: The solar wind was indicative of the arrival of a slow CME, but with some dense magnetic material, followed by a transition into CH99/+ HSS. This CME has been attributed to a reconfiguration of the magnetic field to the northeast of CH99 on the 02 May, with the subsequent Earth-directed CME obscured by a larger far-sided halo CME. Observed speeds at L1 were initially at background at 340 km/s, but suddenly rose to 370 km/s with the CME arrival at 06/0025 UTC. Speeds then erratically climbed to be elevated at 500-550 km/s by 06/1200 UTC. The density also rose from below background to 15-35 ppcc 06/0025 UTC until 06/0500 UTC, then remained largely above average. The total IMF strength, Bt, also increased from background at 06/0025 UTC becoming strong with peak 18nT at 06/0411 UTC, before erratically declining to Moderate levels. The north-south, Bz, component likewise became strongly negative (southward) 06/0100-0400 UTC, with minimum -17nT, before rotating to be positive (northward) directed with maximum 17nT. The magnitude then gradually eased, but varied remained variable between northward and southward directions. The phi angle was initially negative (towards the Sun) but rotated to be mainly positive (away from the Sun) from 06/0330 UTC. Geomagnetic activity was initially Quiet (Kp0-1), but become Unsettled to Active (Kp3-4) from 06/0000 UTC, with one G2 Moderate storm (Kp6) interval observed 06/0300-0600 UTC.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) as measured at GOES16, has been at background levels throughout. High energy electron flux (greater than 2MeV) as measured at GOES16, was initially at High levels, peaking at 5020pfu at 05/1645UTC, but dropped out from 05/0000 UTC to fall to background due to the CME arrival. The 24-hour integrated fluence was at Active levels, but declining. At 06/0000 UTC 2.54e8 integrated pfu was recorded.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity is expected through the next four days with an ongoing likelihood of M-flares, and subsequent R1-R2 blackouts.

Solar Wind / Geomagnetic Activity: Two CMEs which left the Sun on 04 and 05 May

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

respectively, are forecast to arrive on day 2 (07 May), perhaps concurrently, with a risk of effects into 08 May. These are low confidence, due to low confidence with their speeds, how they interact and uncertainties with how much material will be within them. Current elevated solar winds are due to the combined influence of CH99 HSS and a CME arrival early on day 1 (06 May). These elevated winds are expected to gradually ease through the period, once any CME influence has passed. Quiet to Active geomagnetic conditions, with a likelihood of further G1 Minor Storm intervals are expected at first day 1 (06 May). Any CME arrivals are then expected to bring a spell of G1-G2 Minor to Moderate storms, with a chance of G3 Strong storms. This risk recedes later day 3 and day 4 (07 and 08 May) with activity becoming mainly Quiet to Unsettled.

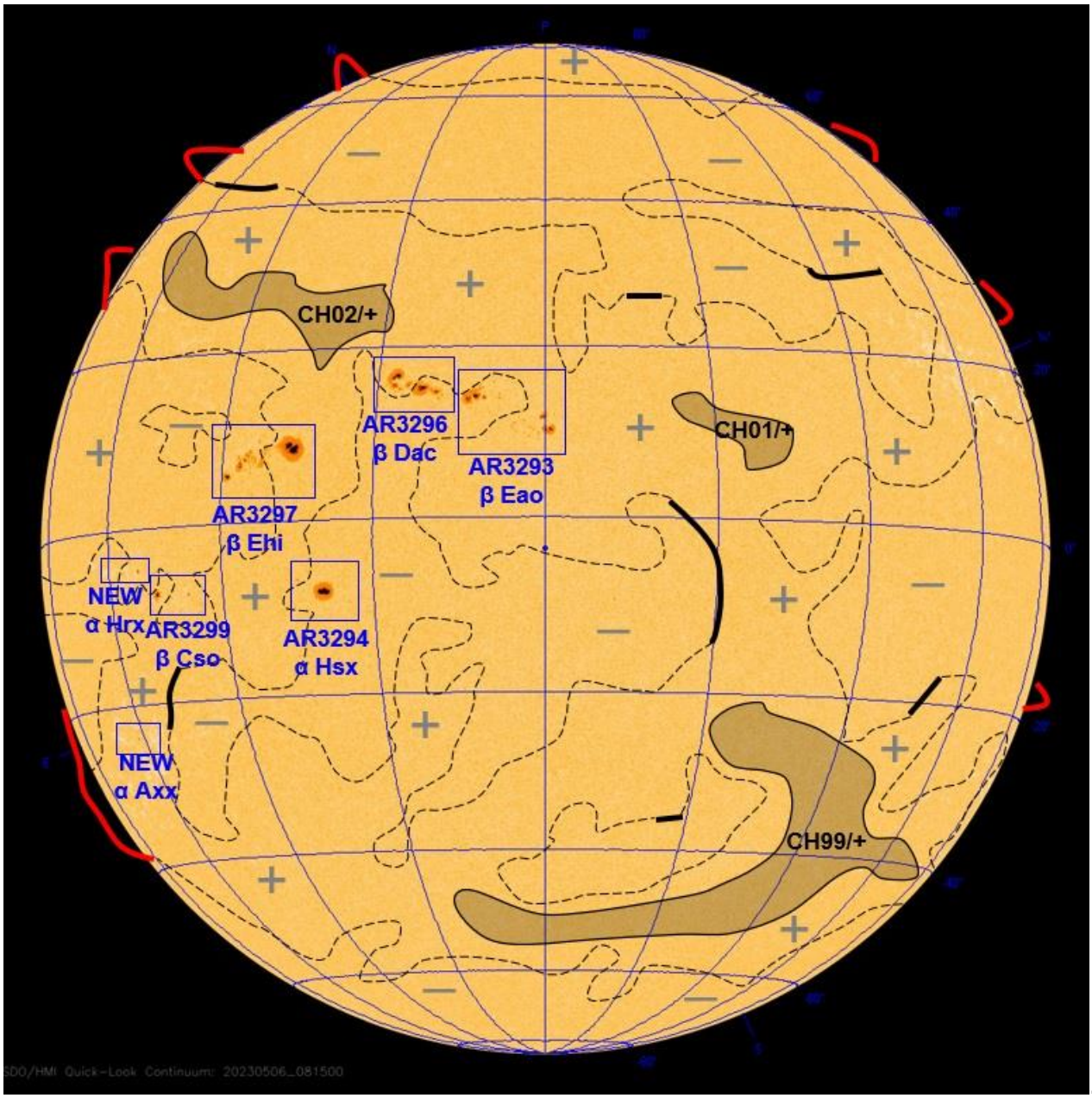
Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is most likely to persist at background with no solar radiation storms occurring. High energy (greater than 2MeV) electron flux is expected to persist at background levels, perhaps rising to Moderate, potentially High later day 3 or day 4 (07 or 08 May). The associated 24 hour fluence is forecast to persist below the Active threshold.

Figure 1.1: L1 observed solar winds

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 1.2. Solar Analysis Valid 06/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Geomagnetic Storms:

Ongoing CME effects on day 1 (06 May) have the potential to be followed by further, but low confidence CMEs, perhaps later day 1 but most likely day 2 (07 May).

The first CME, associated with an M3.9 flare from AR3296 on 04 May, is a complex eruption with the main ejecta to the east, behind Earth, but also a full halo shock observed. This shock has a clear Earth-directed component, but may also include some material or a glance from the ejecta. The second CME is another complex eruption that likely originates from an M2.1 flare of AR3296 early on 05 May. This occurred very soon after a C9-flare from AR3297, and complicated further by a nearby limb E-limb CME that occurred previously. This also has an eastward ejecta component visible, and a clear Earth-directed halo shock.

After reanalysis, the first is now considered most likely to arrive early on day 2 (07 May), with the second arriving during the second half of day 2. However, given the faster speed of the second CME, there is the potential for these to arrive together as a single CME. There is also significant uncertainty over the analysis, with arrivals possible as early as late day 1 (06 May) or as late as early day 2 (08 May). Furthermore, there is also uncertainty with how much material is within the CMEs, and hence how much of an impact will be observed.

Otherwise Earth has likely connected to the fast wind from the HSS of CH99, with elevated winds day 1 (06 May) expected to gradually ease once any CME influence has passed, day 3 onward (07 May).

Quiet to Active conditions, with a likelihood of further G1 Minor Storm intervals are expected at first day 1 (06 May). Any CME arrivals are then expected to bring a spell of G1-G2 Minor to Moderate storms, with a chance of G3 Strong storms. This risk recedes later day 3 and day 4 (07 and 08 May) with activity becoming mainly Quiet to Unsettled.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	60	70	70	20
Strong	G3	No	5	25	20	1
Severe	G4	No	1	2	2	1
Extreme	G5	No	1	1	1	1

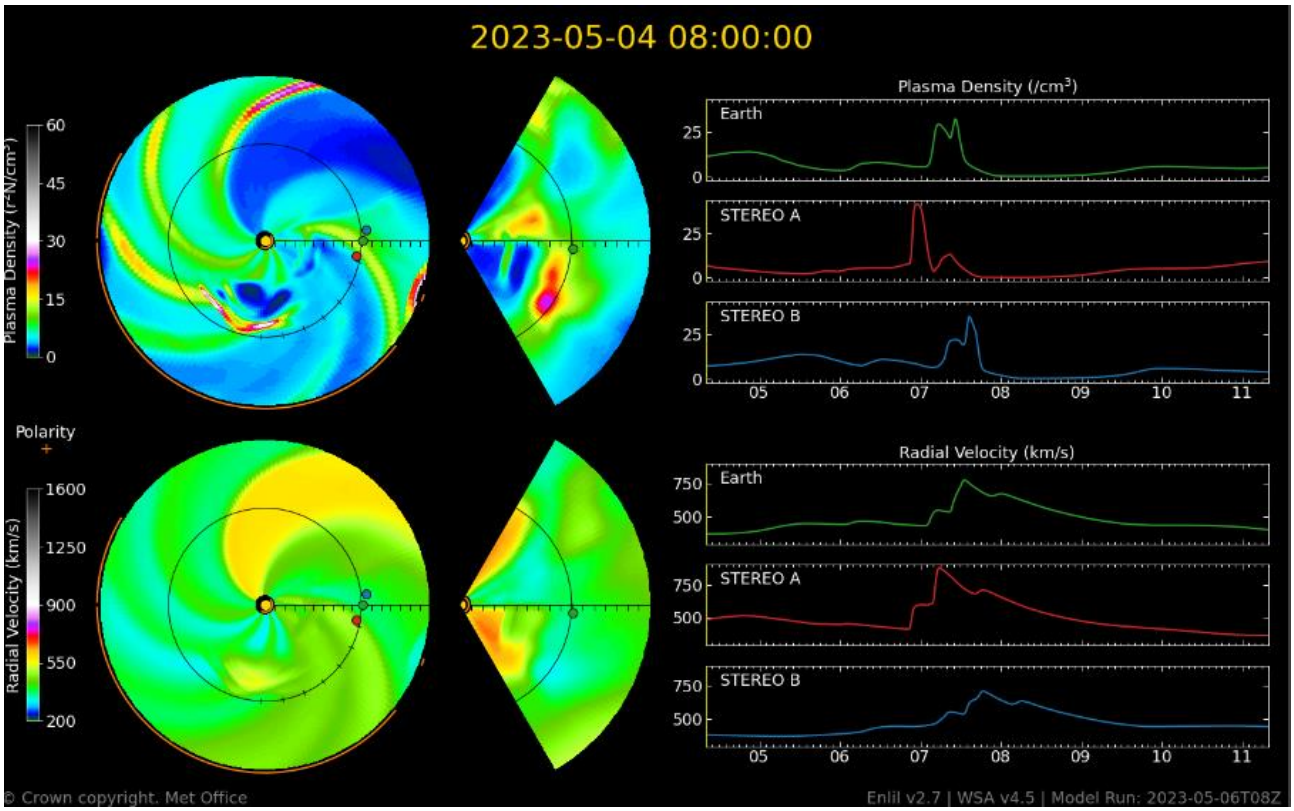
Geomagnetic Activity - Earthbound Coronal Mass Ejections

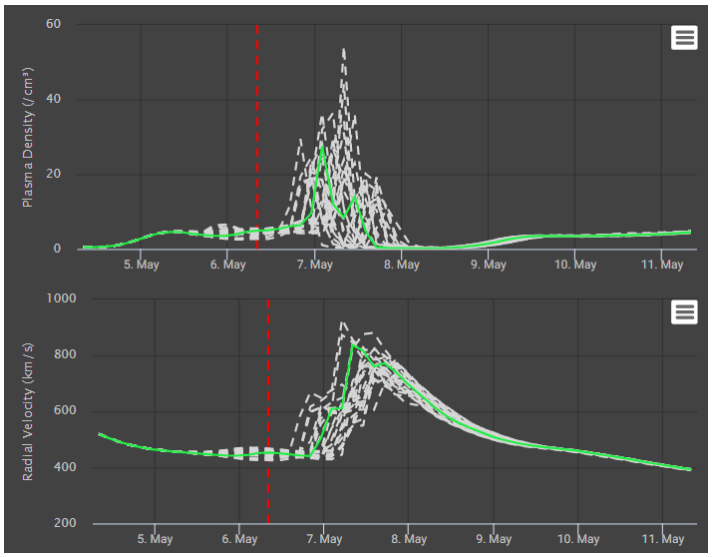
Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
04/1440	Full	M3.9 flare AR3296	NE	720 km/s	07/1200 +/ 12 hours	Very low confidence.
0/0700	Full	M2 flare AR3296	NE	950	07/1800 +/ 12 hours	Very low confidence

Figure 2: Enlil and ensemble

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.





Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

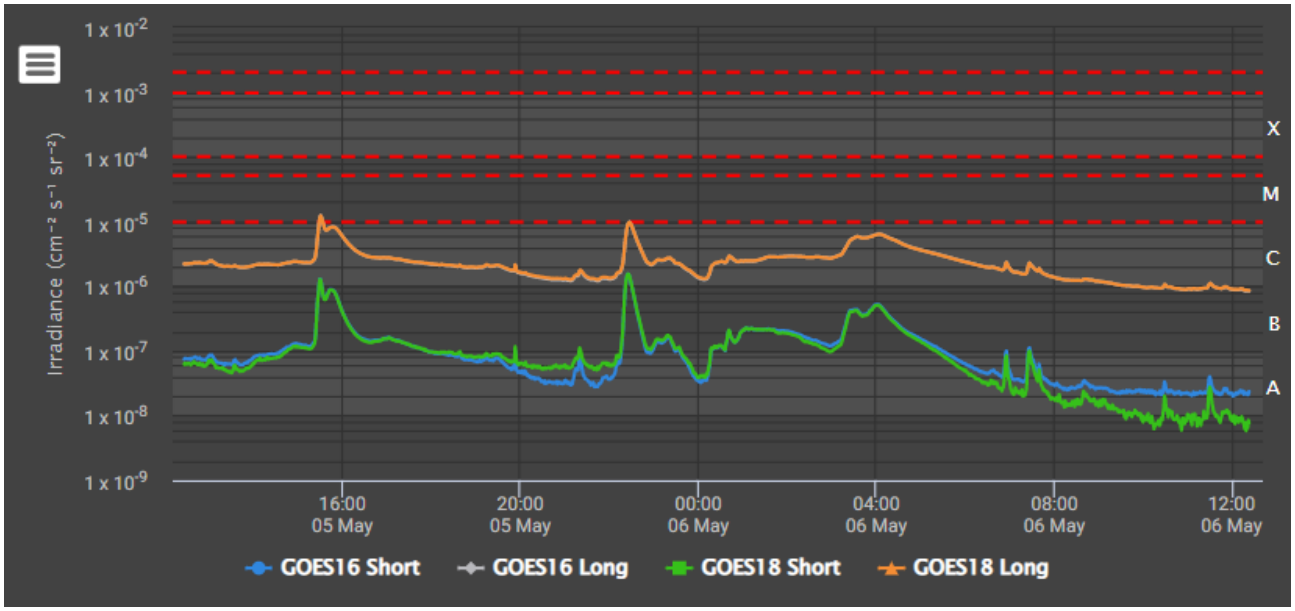
Radio Blackouts - X-Ray Flares:

Moderate activity is expected to continue with an ongoing likelihood of isolated M-flares.

The main activity continues to be from the trio of northeastern disc spots, AR3293, AR3296 and AR3297. This is despite a slight stabilising trend, with no clear flux emergence or recent growth occurring. The main complexity of the group is the reverse polarity (anti-Hale cycle) of AR3296, which brings a greater risk of the development of twisted magnetic fields, however the lack of any visible delta spots or more complex magnetic structure slightly reduces this potential for notable flares compared to recent days. The other groups are currently smaller and simpler, although some slow development is occurring around the leader of AR3299 in the southeast.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	70	70	70	70
Very Active	R3 to R5 X Class	No	15	15	15	15

Figure 3: GOES-16/18 X-ray flux



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux as observed by GOES-16 is most likely to persist at background levels. However, count rates may increase with any significant flares that occur. This most likely from AR3288 just over the east limb on day 1 (05 May) or from any of the trio of sunspots in the northeast disc.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

The electron forecast is of particularly low confidence, especially beyond day 2 (07 May) as it will be dependent upon the arrival of CMEs, which have a large amount of uncertainty on them.

High energy electron flux dropped (greater than 2MeV) observed by GOES-16 at GEO, dropped out to background levels early on day 1 (06 May) due to the arrival of a CME. These background levels are expected to largely persist day 1, 2 and into day 3 (06-07 May) due to the likelihood of further CME arrivals. As the geospace environment eases on day 3 and into day 4 (08 May), electron count rates at GEO have the potential to rise again. This may allow diurnal peak to reach Moderate levels, with a chance of reaching High.

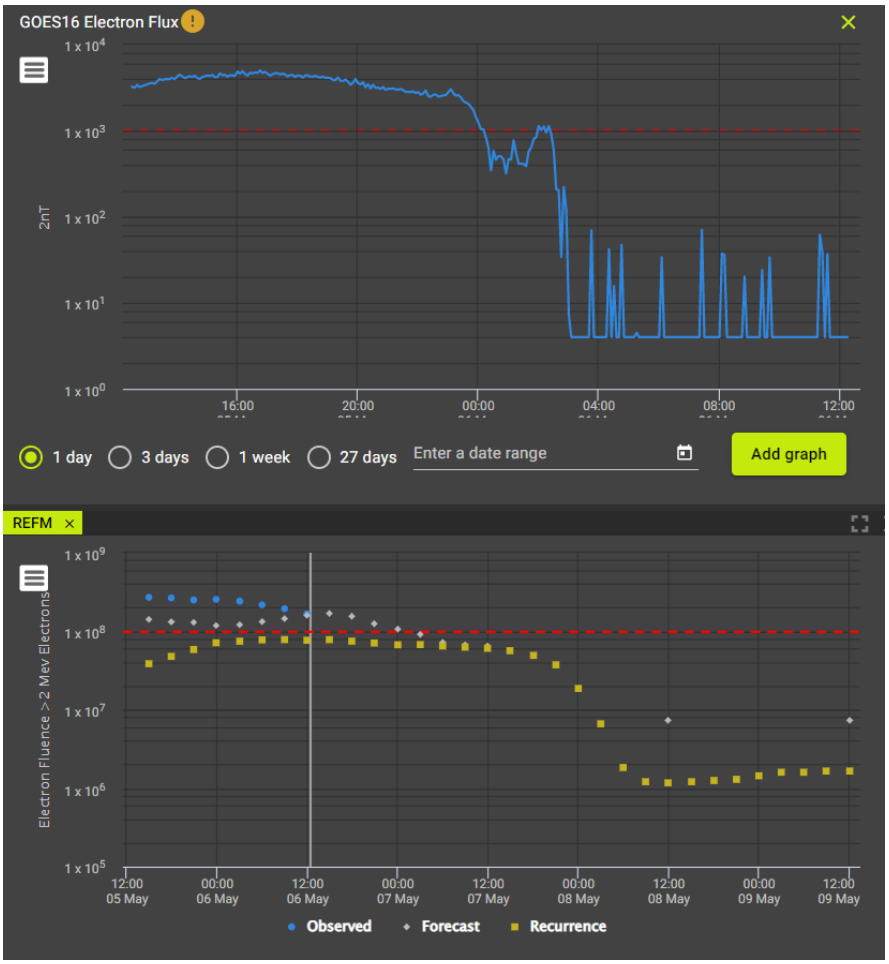
The associated 24 hour fluence is expected to fall below the active on level day 1 (06 May), and then persist at this level, with only a slight chance of rising again by the end of day 4 (08 May). REFM is likely to be unreliable in the forecast period due to arrival of CMEs.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	Yes	100	1	5	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 4: GOES-16 Electron Flux and Fluence with REFM



© Crown Copyright 2023. All Rights Reserved.